Non-Governmental Public Norm Enforcement in Large Societies as a Two-Stage Game of Voluntary Public Good Provision.

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Non-Governmental Public Norm Enforcement in Large Societies as a Two-Stage Game of Voluntary Public Good Provision[‡]

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Abstract

In small groups, norm enforcement is achieved through mutual punishment and reward. In large societies, norms are enforced by specialists such as government officials. However, not every public cause is overseen by states, for instance those organized at the international level. This paper shows how non-governmental norm enforcement can emerge as a decentralized equilibrium. As a first stage, individuals voluntarily contribute to a non-governmental agency that produces an incentive system. The second stage is the provision of a public good on the basis of private contributions. The incentive system punishes and rewards deviations from the norm for contributions by means of public approval or disapproval of behavior. It is shown that, even in large populations, non-governmental norm enforcement can be supported in a non-cooperative equilibrium of utility-maximizing individuals.

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Keywords: norm enforcement, public goods, aggregative games, institutions, non-governmental organizations.

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‡ A first version of the basic idea of this paper was presented in a working paper by *Falkinger* [2004]. This new version of the paper exploits the Aggregative Game Approach as developed by Cornes and Hartley (2003, 2007) in order to analyze this idea in a more general and comprehensive way. For this purpose Josef Falkinger asked Wolfgang Buchholz and Dirk Rübbelke to join him as authors. Some of the research by Dirk Rübbelke on this paper was conducted during his stay at the Australian National University in Canberra in 2011.
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1. Introduction

In small groups, mutual punishing and rewarding promotes the compliance of the individual members of the group with the prevailing norms. In large groups, or at the level of entire societies, the implementation of punishments and rewards is delegated to specialists. Usually we think of the state as the institution responsible for norm enforcement. But in some contexts, there may be no state with coercive power available. Global public goods are the most salient examples of this type of situation.[1] Although governmental power may be expanded by means of international contracts between national governments, this is not the only possibility. We can also observe non-governmental agencies developing normative powers. For instance, environmental organizations run campaigns intended to induce consumers or firms to contribute to environmental quality.

Such non-governmental activities have the following economic structure: A set A of individuals provides in the form of voluntary contributions e_j, $j \in A$, a certain volume of resources $E = \sum_{j \in A} e_j$, for financing an enterprise that exerts social pressure by means of public approval or disapproval of behavior. The system is targeted at a group B of individuals who contribute $e_i, i \in B$ to a public good $G = \sum_{i \in B} g_i$. Approval or disapproval of contribution behavior to the public good establishes a norm.

Sets A and B may be distinct in some cases, while in other cases they may overlap or coincide. Political pressure, partly organized by environmental groups, was exerted on producers of detergents containing phosphates in the 1970s (see, e.g. *Stø, Throne-Holst and Vittersø* [2005, p. 333]), for example, and the specific individual group of companies targeted by the protests was not congruent with the group of financiers supporting the involved environmental groups. Some environmental groups however target potentially everybody, e.g. by stigmatizing to fly by plane since flying strongly contributes to global warming.[2] In such cases there is obviously some degree of overlap between the target group and the group of financiers. This paper provides an economic explanation as to why rational in-

[1] *Cowen* [2002] considers norms that may potentially solve public good problems. His analysis is based on the 'esteem theory' which postulates that granting of esteem is costless such that no free-rider problem is involved in the supply of esteem (*Cowen* [2002, p. 211]). Also see *Brennan and Brooks* [2007].

[2] Some of these groups simultaneously sell carbon offsets. The purchase of such offsets can be regarded as public good provision (climate protection) motivated, in part, to compensate for activities diminishing the public good (stable climate).

dividuals voluntarily contribute to E, even when this forces them (as members of B) to comply with some norm regarding contributions to G.

Behavioral economics has provided insights into how cooperation in groups can be sustained by altruistic punishment and altruistic rewarding (*Fehr and Gächter* [2000, 2002], *Fehr and Fischbacher* [2003]). Such enforcement is based on personal interaction between agents. In large associations, effective norm enforcement is more formal and often involves professional staff. *Yamagishi* [1986], for instance, proposed a distinction between "elementary cooperation" and "instrumental cooperation". Since in large groups it is not possible to guarantee elementary cooperation by means of mutual control, people cooperate at an instrumental level by establishing a sanctioning system. He supports this idea with experimental evidence.[3] *Elster* [1989, p. 100] distinguished between social and legal norms: "Legal norms are enforced by specialists ... social norms are enforced by members of the general community." It is important to note that the state is not the only example of an institution that practices norm enforcement through specialists.

In the case of government enforcement, a central authority stipulates how much citizens must contribute to the public good G as well as to the funds E required for financing the police and the tax officials who enforce the prescribed contributions. What non-governmental agencies have in common with governments is the basic economic fact that resources E have to be invested in manpower and technical equipment with the purpose of effectively inducing contributions to G. But the two institutions also differ in two important respects which is due to the divergence in their disposability of means of coercion. First, non-governmental norm enforcement, as considered in this paper, must induce contributions to G by means of incentives rather than coercive power. Second, non-governmental bodies only command resources E raised through voluntary contributions in a non-cooperative equilibrium.

In order to explain non-governmental norm enforcement as an outcome of decentralized decision-making by free and rational individuals, contributions to public goods are modeled as strategies in a non-cooperative game (*Cornes and Sandler* [1996]). Agents are endowed with an economic resource and can choose between private consumption and a pure public good (the intrinsic public good). At Stage 1, they individually decide how much of their en-

[3] *Carpenter* [2007] has shown in recent experiments that it is indeed the limited capacity of individuals to personally monitor others that renders mutual monitoring less effective in larger groups.

dowment they will pay to an enforcement agency.[4] In the second stage, the individuals decide how much they will contribute to the (intrinsic) public good. Without norm enforcement, the intrinsic public good is supplied inefficiently because of free-riding. In particular, per-capita contributions decrease and eventually vanish if population size increases. The enforcement agency increases the incentive to contribute to the public good by using the funds raised at Stage 1 to exert social pressure that punishes agents contributing less than the norm and rewards those contributing more.[5] The larger the enforcement funds provided at Stage 1, the more powerful are the punishments and rewards. The norm is defined by the average contribution.[6]

The reason why effective public norm enforcement can emerge as a decentralized equilibrium of utility-maximizing individuals derives from interacting external effects in the contribution games to E and G. As *Coleman* [1990, p. 251] pointed out, interests in a norm arise when "an action has similar externalities for a set of others". The positive external effects of a public good supplied by other individuals lead to underprovision in a non-cooperative equilibrium. This inefficiency explains why there is a need for a norm that induces individuals to contribute to the public good, and this need is a potential opportunity for entrepreneurial activity. People are willing to pay for an enterprise that internalizes the positive externalities of public good provision through appropriate incentives. By contributing to E at Stage 1, an individual can penalize free-riding at Stage 2. This paper shows that such non-governmental norm enforcement is supported by substantial voluntary contributions even if the size of the population is large. However, the sanctions and rewards produced are not always sufficient to overcome free-riding in the G-contribution game at Stage 2.

The paper is organized as follows. Section 2 discusses related work on organizations and institutions. Section 3 outlines the basic model and the Aggregative Games Approach (developed by *Cornes and Hartley* [2003, 2007]). Section 4 deals with the scenario where

[4] This corresponds to *Yamagishi*'s [1986] experimental design for testing "instrumental cooperation".

[5] In principle, the agency could use other incentive schemes, for instance, one of sanctions only. However, any approval or disapproval based on relative performance comprises both a punishment and a reward component. Moreover, it is reasonable to use both tools. For instance, experiments by *Andreoni, Harbough, and Vesterlund* [2003] show that "cooperation ... is most successfully enforced in an environment in which both punishments and rewards are available" (p. 901).

[6] It is known that punishing and rewarding deviations from an average can induce efficient contribution levels with respect to a public good. See *Falkinger* [1996] for a theoretical analysis and *Falkinger et al.* [2000] or *Bracht, Figuères, and Ratto* [2008] for behavioral evidence in laboratory experiments. *Chen* [2005] discusses stability and learning properties.

groups A and B differ. We analyze the subgame perfect equilibrium and in order to investigate the comparative statics, we apply specific functions to the model. In contrast, in Section 5, the whole population is targeted by the sanction mechanism, while group A may be smaller. Again we consider the equilibria for the general case, but in order to determine the comparative-static properties of the model, we consider specific utility functions and reward mechanisms. We illustrate the functioning and effectiveness of the reward scheme by ascertaining numerical results for both the case where there is rivalry in the norm-enforcement and the case where norm-enforcement is non-rival. Section 6 summarizes the results.

2. Related Literature

The problem of individual support for public norm enforcement is related to the formation of organizations. As *Olson* [1965] pointed out, an important characteristic of organizations is "the furtherance of interests of their members", that is, the provision of some collective good. And "just as a state cannot support itself by voluntary contributions ... neither can other large organizations support themselves without providing some sanctions ... that will lead individuals to help bear the burdens of maintaining the organization" (p. 15). Seen from this perspective, the question that arises is why individuals join an association and submit to the rules of that association in the first place. In our analysis, membership contracts with rights and duties play no role. Instead, non-governmental organizations are seen as enterprises in which individuals can invest. In return, rather than financial dividends, the individuals receive (indirectly) increased contributions to a public good they appreciate.

A related issue is the emergence of states. Following *John Locke*, the theory of social contracts has argued that "rational individuals, each possessing natural rights, will engage in a joint social contract to give up to a central authority those rights which if held and exercised centrally will make them better off" (*Coleman* [1990, p. 328]).[7] Such an approach focuses on the legitimacy of a central authority, as opposed to anarchy or dictatorial usurpation. The economic approach presented in this paper does not start with a virtual state of nature, nor is it normative. The object of the analysis is an economy at a given point in time, characte-

[7] Thomas Hobbes' concept of Leviathan conveys "the idea that each subject authorizes the sovereign's acts and defines authorization as creating an identity between sovereign and subject that precludes accountability" (Baumgold [2010, p. 8]).

rized by the usual fundamentals: preferences, endowments, and production possibilities. Production possibilities include the technology by means of which endowments can be transformed into the production of sanctions and rewards. This technology may be as simple as agents watching people's behavior and assessing it according to a benchmark. But scientific methods of investigation or the use of mass media are also components of modern enforcement technologies.[8] They enable disapproval of undesired, and praise for desired behavior on a large scale. Just as technical progress increases productivity in the construction of private goods, innovations in the feasible means of control and sanctioning change the possibilities of norm enforcement. As there is no central government that can enforce norms internationally, there is an important role of *international* non-governmental organizations in promoting and enforcing norms (see, e.g. *Finnemore and Sikkink* [1998]). Such norms may not only influence individual agents, but as *O'Neill, Balsiger and van Deveer* [2004] stress, some non-state actors are even capable "to influence incentives, beliefs, and preferences of states […] and hence shape the terms and direction of international cooperation" (p. 158).[9] *Brown and Moore* [2001] remark that international non-governmental organizations have become increasingly important in "animating informal but powerful normative regimes" (p. 569). With respect to international non-governmental organizations *Boli and Thomas* [1997, p. 181] point to the instance that although they have little sanctioning power, "[t]hey make rules and expect them to be followed; they plead their views with states or transnational corporations and express moral condemnation when their pleas go unheeded".[10]

Moreover, just as with private production technologies, the fact that a certain public enforcement technology is feasible does not mean that it is actually used. Generating output requires employment of input. The analysis presented here explains the contribution of resources to operate the enforcement technology. Since, by assumption, the resources are

[8] State institutions such as courts may also be used as leverage for non-governmental norm enforcement. It is also true, however, that state institutions limit the feasible technology for non-governmental enforcement to legal instruments.

[9] *Johansson-Stenman and Konow* [2010, pp. 154-155, 158] consider the *equality norm* in the context of fairness and they argue that (even undemocratic) governments "are usually subject, to some degree, to the views and passions of their constituents, and fairness likely plays a significant role in the motives of the latter."

[10] Non-governmental organizations on a sub-national level may punish or reward individual people's behavior not exclusively by generating some kind of social pressure but, as *Kotchen* [2009, p. 884] indicates with respect to some religious groups, also by claiming monetary penance for acts violating a respective group's rules or norms.

given voluntarily by free and rational agents, legitimacy is not an issue. The problem is to attain efficiency and, in particular, whether or not support of public norm enforcement breaks down if the number of individuals becomes very large and there is no personal relationship to control free-riding.[11]

Finally, the analysis is related to *Okada*'s [1993, 1997] non-cooperative approach to social organizations.[12] Also discussed in *Okada*'s work is the possibility of individuals giving to a professional enforcement agency the economic means to sanction free-riding. However, in this case, they have to join a social organization that collectively decides on the strength of punishment and the allocation of enforcement costs among members. Moreover, only members of the organization are subject to enforcement. Non-members can free-ride the benefits of the social organization. In this paper, by contrast, individuals need not enter into a social relationship and negotiate or vote on the resources spent on enforcement. No collective decision-making is involved at any stage. Each individual decides on his/her own how much to give to the enforcement agency. Moreover, the punishment-reward scheme implemented by the agency can be targeted at any set of agents, regardless of an agent's support of enforcement through his/her own investments. This is an important feature of non-governmental public norm enforcement by means of incentive schemes, in contrast to norm enforcement by means of regulations within an association. A consumer cannot choose whether or not to be exposed to a campaign against the fur trade by organizations for animal protection. Nor can firms avoid being under the spotlight of environmental groups or escape public discussion of social responsibility. And whether policemen contribute or not to human rights watch organizations, they are still subject to observation and critical assessment by such organizations. The basic assumption of this paper is that the efficiency and the economic resources of non-governmental enterprises determine how much pressure their approval or disapproval exerts on the subjects in their focus.

[11] Whereas the normative approach of social contract theory addresses the legitimacy of institutions by asking which contract individuals would sign, this positive analysis asks how many resources individuals contribute to first- and second-level public goods in a non-cooperative equilibrium.

[12] See *Kosfeld and Riedl* [2007] for a discussion of experimental evidence on decentralized individual punishment in comparison to the formation of a centralized sanctioning institution in Okada's theoretical set up. Here, individuals can decide whether or not to participate in a club (participation stage) whose members vote on or negotiate whether or not to implement a punishment institution (negotiation stage) that enforces provision of a public good among club members (contribution stage). Also see *Kosfeld, Okada, and Riedl* [2009].

3. General Framework

The economy consists of a set $N = \{1,...,n\}$ of $n \geq 2$ individuals $i = 1,...,n$ with preferences over private consumption c_i and a public good G, represented by the identical utility function $u(c_i, G)$, which is twice partially differentiable in both arguments with partial derivatives $u_1 = \frac{\partial u}{\partial c_i} > 0$ and $u_2 = \frac{\partial u}{\partial G} > 0$, and for which the private and the public good are strictly normal. Furthermore we assume that $u(c_i, G)$ has indifference curves which, as in the Cobb-Douglas case, are tangential to the coordinate axes. Here, private consumption has a broad meaning and includes, beyond material consumption, some feeling of social esteem.[13] For the sake of simplicity the price of private consumption and the price of the public good are normalized to 1. Each agent i is endowed with a gross income y_i. The public good G is supplied in a non-cooperative contribution game by some group $B \subseteq N$ of size n_B (with $2 \leq n_B \leq n$) which has aggregate income $Y_B = \sum_{i \in B} y_i$. The public good contribution of agent $i \in B$ is denoted by g_i, and – assuming a summation technology - public good supply is $G = \sum_{i \in B} g_i$.

Through an increase in social esteem, public approval of public good provision augments private well-being of each agent $i \in B$ by $r_i > 0$, while disapproval reduces it by $r_i < 0$. Conversely, this means that agent i has to expend $c_i - r_i$ of her initial income y_i to have private consumption c_i. Thus agent $i's$ budget constraint is

(1) $$c_i + g_i = y_i + r_i$$

The sanction level that ascertains the degree of approval of agent $i \in B$ depends on the difference between her own contribution to the public good and the average contribution made by the other members of group B, such that

(2) $$r_i = \beta(g_i - \frac{1}{n_B - 1} \sum_{j \in B \setminus \{i\}} g_j).$$

In the punishment-reward scheme as described by eq. (2) the parameter β indicates the strength of (positive or negative) sanctions that agent $i \in B$ experiences when she deviates

[13] As *Becker* [1974, pp. 1066-1067] points out, an agent can improve the value of his social environment by achieving distinction, e.g. by giving to charities. Distinction is largely a private characteristic like those private merits an agent obtains from purchasing a conventional private good.

from average public good contributions as the norm. This gives a motive to care more about the public good – not because of some 'warm glow effect' in the sense of *Andreoni* [1990], but due to the approval and disapproval of deviations from the norm.[14]

Norm compliance induced by internalized psychological control mechanisms would mean that the punishment-reward strength parameter β is exogenously given without requiring any economic resources. Here, however, it is supposed that β is endogenous and depends on the expenditures E that are made for establishing and operating an enforcement agency. Hence, $\beta = \beta(E)$ which is assumed to be a twice differentiable function of E which has $\beta(0) = 0,\ \beta'(E) > 0$ and $\beta''(E) < 0$. More resources allow for a higher degree of enforcement, for instance by more frequent inspection and more effective monitoring of contribution behavior ($\beta'(E) > 0$), while the marginal productivity of enforcement expenditures is non-increasing ($\beta''(E) < 0$).

Under non-governmental norm enforcement, E is also a public good whose supply is determined in another non-cooperative game through contributions made by a group $A \subseteq N$. If e_i denotes the contribution of agent $i \in A$ to the enforcement fund the total size of this fund is $E_A = \sum_{i \in A} e_i$. The groups A and B may be disjoint or overlap and then even comprise the whole economy, i.e. $A = B = N$. In any case, we have the following two stage game: At stage 1, the agents from group A non-cooperatively contribute to the enforcement fund E run by a non-governmental agency. At stage 2, the agents from group B non-cooperatively contribute to the public good G under the punishment reward scheme described by eq. (2). We intend to characterize subgame-perfect equilibria of this two-stage game. As a first step we apply the Aggregative Game Approach developed by *Cornes and Hartley* [2003, 2007] to analyze the equilibria which result for a given size E_A of the enforcement fund at stage 2 of the game.

Under the punishment-reward scheme given by eq. (2) for each agent in group B the effective price of the public good is changed to $1 - \beta(E_A)$ and the marginal rate of transfor-

[14] "Humans regularly exhibit a culturally conditioned sense of fairness, and they are willing to enforce cultural norms even at economic cost to themselves"(*Gowdy* [2008, p.633]); also see *Chaudhuri* [2011, p. 49]. Yet, as we show, net economic cost of supporting norm-enforcing mechanisms may be negative.

mation between the private good and the public good G becomes $\mu(E_A)=\dfrac{1}{1-\beta(E_A)}$ (see *Falkinger* [1996]). The assumptions made for $\beta(E_A)$ imply that $\mu'(E_A)>0$ and $\mu''(E_A)<0$.

In an interior stage 2-equilibrium where all agents in B make a strictly positive contribution to the public good G the marginal rate of substitution must be equal to $\mu(E_A)$. For any marginal rate of substitution μ between the private and the public good we now denote an agent´s consumption expansion path by $h(G,\mu)$ with partial derivatives $h_1=\dfrac{\partial h}{\partial G}>0$ and $h_2=\dfrac{\partial h}{\partial \mu}<0$ (from quasi-concavity of the utility function and normality of both goods).[15] Then, given some E_A, each agent $i\in B$ has private consumption

(3) $$c_i=h(G,\mu(E_A))$$

in an interior stage 2-equilibrium, if public good supply is G.

For a characterization of the stage 2-equilibrium by means of the Aggregative Game Approach the aggregate budget constraint for group B has to be observed such that public good supply $\hat{G}(E_A,E_B)$ at stage 2 depends on E_A and E_B and is then implicitly given by

(4) $$\hat{G}(E_A,E_B)+n_B h(\hat{G}(E_A,E_B),\mu(E_A))=Y_B-E_B.$$

In this aggregate budget constraint the individual rewards and punishments r_i do not matter since it directly follows from eq. (2) that $\sum_{i=1}^{n} r_i=0$. Clearly, $E_B\le E_A$. Eq. (4) provides the key for the whole subsequent analysis. To examine behavior of group A at the first stage of the game and thus to determine subgame-perfect equilibria we now focus on two special cases: In the first one A and B are disjoint subsets of N, in the second one we assume $A\subseteq N$ and $B=N$.

[15] Instead of the term 'consumption expansion path' the expression 'income expansion path' is employed frequently in the literature, but we think that the term 'consumption expansion path' fits better in the context of a public good economy.

4. Sanctioning Other People´s Behavior

We first consider the case of a non-governmental agency that focuses sanctions on a strict sub-population $B \subset N$ and invites the rest of the population $A = N \setminus B$ of size $n_A = n - n_B$ (with identical individual incomes y_A and aggregate income $Y_A = n_A y_A$) to contribute to the enforcement fund E. Group $A's$ contributions to the enforcement fund are E_A, which is employed to induce public good provision by subpopulation B. The function $\mu(E_A)$ which indicates the effectiveness of sanctions will only depend on the level of aggregate payments E_A to the enforcement fund but not on the size n_A of the sanctioning group A. But it may well be possible that sanctions become less effective when the size n_B of the sanctioned group B grows, i.e. $\mu(E_A)$ may be falling in n_B. Members of A do not participate in the provision of G, while members of B do not participate in the provision of E, i.e. $E_B = 0$ in eq. (4). For the sake of abbreviation we define $\hat{G}^{(1)}(E_A) := \hat{G}(E_A, 0)$ where $\hat{G}(E_A, 0)$ is defined by (4) given the disjoint groups A and B.

The function $\hat{G}^{(1)}(E_A)$ which is twice differentiable for all E_A defines a (normally non-linear) indirect contribution 'technology' for the public good *G*. By taking the derivative of (4), the marginal rate of transformation between the fund E_A and public good *G* is

$$\text{(5)} \qquad \frac{d\hat{G}^{(1)}}{dE_A} = -\frac{n_B h_2(\hat{G}^{(1)}(E_A), \mu(E_A))\mu'(E_A)}{1 + n_B h_1(\hat{G}^{(1)}(E_A), \mu(E_A))} > 0 .$$

The inequality in (5) holds since $h_1 > 0$ and $h_2 < 0$. Given some level of E_A, an agent in group A has an incentive to increase unilaterally her contribution to the investment fund if and only if

$$\text{(6)} \qquad -u_1(y_A - e_A, \hat{G}^{(1)}(E_A)) + u_2(y - e_A, \hat{G}^{(1)}(E_A)) \frac{d\hat{G}^{(1)}}{dE}(E_A) > 0$$

for $e_A \geq 0$.

Based on inequality (6) it is now possible to characterize the symmetric interior stage 1-equilibrium $(e_i^*)_{i \in A}$ with $e_i^* = e_A^* = \dfrac{E_A^*}{n_A}$.

Proposition 1: Let the whole population be divided in a group A which only contributes to the enforcement fund E and a disjoint group B which only contributes to the public good G. Then the contribution e_A^* which each agent from group A makes to the enforcement fund in the subgame perfect equilibrium is given by

(7) $$mrs_A := \frac{u_1(y_A - e_A^*, \hat{G}^{(1)}(n_A e_A^*))}{u_2(y_A - e_A^*, \hat{G}^{(1)}(n_A e_A^*))} = \frac{d\hat{G}^{(1)}}{dE}(n_A e_A^*) =: mrt$$

where the *mrt* is given by eq. (5).

For sufficiently large n_B, existence of an equilibrium that fulfills condition (7) is ensured if in addition to the conditions imposed above the following is assumed: h_1 and h_2 are continuous for all $G \geq 0$ and $\mu \geq 1$, and h_1 and $h_2 \in [a,b]$ for some constants a and b. The left-hand side of (7), i.e. mrs_A, is a continuous function of e_A which – since the indifference curves have been assumed to be tangential to both coordinate axes – converges to infinity if e_A^* goes to y_A. Moreover, it decreases towards a positive value $Z(n_B) := mrs(y_A, G(0))$, if e_A^* goes to 0. Since $G(0)$ declines with n_B eventually approaching zero, $Z(n_B)$ is arbitrarily small if n_B is sufficiently large. The right-hand side of (7), i.e. $\frac{dG^{(1)}}{dE}(n_A e_A)$, is a continuous function of $n_A e_A$ which is bounded from below and from above on the interval $[0,y_A]$. Moreover, for any value of e and n_A, it decreases with n_B, as can be inferred from equation (5) and the fact that h_1 and $h_2 \in [a,b]$. Therefore, for all n_B larger than a threshold $\tilde{n}_B$, existence of an e_A^* that equalizes both sides of (7) follows from the intermediate value theorem.

Comparative statics effects are hard to obtain in the case of a general utility function. As a next step we therefore assume that all agents have the Cobb-Douglas utility function

(8) $$u(c_i, G) = c_i^{\alpha} G^{1-\alpha} .$$

Letting $\rho = \frac{\alpha}{1-\alpha}$, the consumption expansion path for any given $\mu \geq 1$ is

(9) $$h(G, \mu) = \frac{\rho}{\mu} G \ .$$

The equilibrium condition (7) then becomes

$$(10) \qquad \frac{1}{y_A - e_A^*} = \frac{n_B \mu'(n_A e_A^*)}{\mu(n_A e_A^*)(\mu(n_A e_A^*) + n_B \rho)}$$

We can directly infer from (10) how the payments to the enforcement fund change if some exogenous variables change.

Proposition 2: In the Cobb-Douglas case, individual payment e_A^* to the enforcement fund made by an agent from group A in the subgame perfect equilibrium increases if either individual income y_A in group A grows, the preference intensity for the private good ρ or the size n_A of group A fall or, in case that $\mu(E_A)$ is independent of n_B, the size n_B of group B grows. Public good supply decreases when n_A falls, but increases in all other cases.

Proof: The left-hand side of eq. (10) is an increasing function of e_A. From $\mu'(E_A) > 0$ and $\mu''(E_A) < 0$ it follows that the right-hand side of (10) is a decreasing function of $E_A = n_A e_A$. Given the original equilibrium level of e_A^*, all changes described in the Proposition then imply that the left-hand side in (10) becomes smaller than the right-hand side. To restore equilibrium, the level of individual contributions e_A^* to the enforcement fund must increase. Except for the case when n_A changes, the increase in e_A^* directly leads to an increase in aggregate payment E_A^* to the enforcement fund and - through the concomitant increase of $\mu(E)$ - to a higher public good supply at stage 2 of the game. If n_A falls and thus e_A^* increases by the first part of the Proposition, the left-hand side of (10) grows. If then aggregate payments $E_A^* = n_A e_A^*$ increased, the right-hand side of (10) would become larger and no equilibrium could be attained. QED

In general, the degree of enforcement depends on both the volume of available enforcement resources E and the number of agents n_B whose norm compliance is to be controlled. If enforcement is a pure public good without any rivalry in operation, population size n_B plays no role. For instance, public approval or disapproval of behavior requires collection and distribution of information through mass media whose cost does not much depend on the number of the addressees. To account for different degrees of rivalry, which occur if agents have to be controlled individually, and thus to grasp the possibility that in a larger group B sanctions become less effective, we now use the following specification of the enforcement technology:[16]

(11) $$\mu(E_A) = 1 + n_B^{-\gamma} E_A \,.$$

Here the parameter $\gamma \in [0,1]$ represents the degree of rivalry in the use of E, and with $\gamma = 0$, the case of non-rivalry is obtained where $\mu(E)$ does not depend on n_B. In the opposite case with $\gamma = 1$, there is full rivalry instead. For this specific enforcement technology, condition (10) becomes

(12) $$\frac{1}{y_A - e_A^*} = \frac{n_B^{\;1-\gamma}}{(1+n_B^{-\gamma}E_A^*)(1+n_B^{-\gamma}E_A^* + n_B\rho)} = \frac{n_B^{1+\gamma}}{(n_B^{\gamma}+E_A^*)(n_B^{\gamma}+E_A^* + \rho n_B^{1+\gamma})}\,.$$

For this specific situation we have some additional results.

Proposition 3: In the Cobb-Douglas case with an enforcement technology (11) contributions to the enforcement fund are i) increasing in n_B if γ is low and ii) decreasing in ρ.

Proof:

For part (i), check $\frac{\partial\left[\frac{n_B^{1+\gamma}}{\left(n_B^{\gamma}+E_A^*\right)\left(n_B^{\gamma}+E_A^*+\rho n_B^{1+\gamma}\right)}\right]}{\partial n_B} \lesseqgtr 0$, if $(1+\gamma)\left(n_B^{\gamma}+E_A^*\right)\left(n_B^{\gamma}+\rho n_B^{1+\gamma}+E_A^*\right) \lesseqgtr n_B\left\{\gamma n_B^{\gamma-1}\left(n_B^{\gamma}+\rho n_B^{1+\gamma}+E_A^*\right)+\left(n_B^{\gamma}+E_A^*\right)\left[\gamma n_B^{\gamma-1}+\rho(1+\gamma)n_B^{\gamma}\right]\right\}$. The inequality is equivalent to the condition

$$1+\gamma \lesseqgtr \frac{\gamma n_B^{\gamma}}{n_B^{\gamma}+E_A^*} + \frac{\gamma n_B^{\gamma}+\rho(1+\gamma)n_B^{1+\gamma}}{n_B^{\gamma}+\rho n_B^{1+\gamma}+E_A^*}.$$

For γ approaching zero, the left-hand side is equal to one, while the right-hand side becomes $\frac{\rho n_B}{1+\rho n_B+E_A^*} < 1$. Thus, $\frac{\partial\left[\frac{n_B^{1+\gamma}}{\left(n_B^{\gamma}+E_A^*\right)\left(n_B^{\gamma}+E_A^*+\rho n_B^{1+\gamma}\right)}\right]}{\partial n_B} > 0$ and $\frac{\partial E_A^*}{\partial n_B} > 0$.

[16] Hence, we set $\beta(E) = 1 - \frac{1}{1+En_B^{-\gamma}}$. This effective sanctioning rate indicates that sanctioning is the stronger, the higher the payments for E and – provided there is rivalry in norm-enforcement – the lower the number of agents in group B.

Part ii) follows from $\frac{\partial\left[\frac{n_B^{1+\gamma}}{\left(n_B^{\gamma}+E_A^*\right)\left(n_B^{\gamma}+E_A^*+\rho n_B^{1+\gamma}\right)}\right]}{\partial\rho} < 0.$

5. Norm Enforcement with Universal Coverage: Sanctioning Everybody

As a second special case we consider the situation in which the group B whose members contribute to the public good G comprises the whole economy, i.e. $B = N$, and thus $E_B = E_A$, while the group A whose members also contribute to the enforcement may also be equal to N or may, alternatively, be a subgroup of N. All agents in the economy are assumed to have the same income level y. For the sake of abbreviation define $\hat{G}^{(2)}(E) := \hat{G}(E,E)$, where $\hat{G}(E,E)$ is given by (4) for $E \coloneqq E_A = E_B$, and $\hat{c}^{(2)}(E) := h(\hat{G}^{(2)}(E), \mu(E))$. Concerning public good supply and the private consumption levels of all agents, the equilibrium at stage 2 therefore is completely the same irrespective of whether A coincides with the whole group N or is only a subgroup N of arbitrary size. Note that it is a direct implication of the equilibrium condition (4) that each agent in the subgroup A has the same private consumption level in an equilibrium at stage 2 as each agent outside A, which means that any agent´s contribution to the enforcement fund E is completely offset by a reduction of her contribution to the public good G.

Looking at the first stage of the game, the condition that characterizes the level E^* of the enforcement fund in the subgame perfect equilibrium is

$$(13) \qquad u_1(\hat{c}^{(2)}(E^*), \hat{G}^{(2)}(E^*)) \frac{d\hat{c}^{(2)}}{dE}(E^*) + u_2(\hat{c}^{(2)}(E^*), \hat{G}^{(2)}(E^*)) \frac{d\hat{G}^{(2)}}{dE}(E^*) = 0$$

or equivalently, observing that $\mu(E) = \frac{u_1}{u_2}(\hat{c}^{(2)}(E), \hat{G}^{(2)}(E))$ holds for any $E \geq 0$ in the equilibrium at stage 2,

$$(14) \qquad \mu(E_A^*) = -\frac{d\hat{G}^{(2)} / dE_A}{d\hat{c}^{(2)} / dE_A}(E_A^*).$$

Since the size of group A neither matters for this condition, we have the following result:

Proposition 4: If $B = N$, then the subgame perfect equilibrium, as characterized by (14), does not depend on the size n_A of subgroup A. In the subgame perfect equilibrium all agents have the same private consumption level, irrespective of whether they are in group A or not.

For the further analysis we get, now omitting all variables, from (1) and (4) that $\frac{\partial \hat{G}}{\partial E} = -\frac{1+nh_2\mu'}{1+nh_1}$ and $\frac{\partial \hat{c}}{\partial E} = -\frac{h_1 - h_2\mu'}{1+nh_1}$. Then, the equilibrium condition (14) becomes

(15) $$\mu(E^*) = -\frac{1+nh_2\mu'}{h_1 - h_2\mu'}.$$

Since $h_1 > 0$ and $h_2 < 0$, due to quasi-concavity and normality the denominator in (15) is always positive. Thus, as $\mu \geq 1$, $nh_2\mu' < -1$ must hold in a subgame perfect equilibrium.

Based on condition (15) one can show that in the subgame perfect equilibrium the public good G is underprovided in a certain sense.

Proposition 5: Public good supply $\hat{G}(E_A^*)$ in the subgame perfect equilibrium is lower than in the symmetric Pareto optimal solution based on the aggregate initial endowment $Y - E_A^*$, in which all agents have the same level of private consumption.

Proof: Assume that $\mu(E_A^*) \geq n$. Then, as $h_1 > 0$, $h_2 < 0$ and $\mu' > 0$, it follows from (15) that

(16) $$\mu(E_A^*) = \frac{-nh_2\mu' - 1}{-h_2\mu' + h_1} < \frac{n(-h_2\mu')}{-h_2\mu'} = n$$

As for any fixed initial endowment, public good supply is increasing in μ, this implies that $\hat{G}(E_A^*)$ is lower than public good supply in the symmetric solution where - given $Y - E_A^*$ as initial endowment - all agents have the same level of private consumption and their marginal rate of substitution between the private and the public good is equal to n. This solution is Pareto optimal given $Y - E_A^*$, since Samuelson condition $n\mu = 1$ is fulfilled.

For comparative statics exercises we again assume Cobb-Douglas preferences according to (10). Observing that $h_1 = \frac{\rho}{\mu}$ and $h_2 = -\frac{\rho}{\mu^2}G$, condition (15), which characterizes aggregate contributions E_A^* to the enforcement fund in the subgame perfect equilibrium, becomes

$$\text{(17)} \qquad \mu(E_A^*) = -\frac{1 - n\frac{\rho}{\mu(E_A^*)^2}\hat{G}(E_A^*)\mu'(E_A^*)}{\frac{\rho}{\mu(E_A^*)} + \frac{\rho}{\mu(E_A^*)^2}\hat{G}(E_A^*)\mu'(E_A^*)} = -\frac{\mu(E_A^*)^2 - n\rho\hat{G}(E_A^*)\mu'(E_A^*)}{\rho(\mu(E_A^*) + \hat{G}(E_A^*)\mu'(E_A^*))}$$

As $E_B = E_A$ in the special case treated in this section and assuming Cobb-Douglas preferences, condition (4), which gives public good supply in the equilibrium at stage 2, is

$$\text{(18)} \qquad \hat{G}(E_A) + n\frac{\rho}{\mu(E_A)}\hat{G}(E_A) = Y - E_A$$

which implies

$$\text{(19)} \qquad \hat{G}(E_A) = \frac{\mu(E_A)(Y - E_A)}{\mu(E_A) + n\rho}$$

Using (19) in (17) and observing that $\alpha = \frac{\rho}{1+\rho}$, we obtain

$$\text{(20)} \qquad \frac{1}{Y - E_A^*} = \alpha\frac{\mu'(E_A^*)}{\mu(E_A^*)}\frac{(n - \mu(E_A^*))}{(\mu(E_A^*) + n\rho)} = \frac{\mu'(E_A^*)}{\mu(E_A^*)}\left(\frac{n\rho}{\mu(E_A^*) + n\rho} - \alpha\right).$$

Using equation (20) we get the following comparative statics results.

Concerning the enforcement technology we now make the assumption that

$$\text{(21)} \qquad \frac{\mu'(E_A)}{\mu(E_A)} \text{ is non-increasing in } E_A.$$

Assumption (21) is clearly fulfilled when $\mu(E)$ is linear, i.e. $\mu(E) = 1 + \kappa E$. We get the following comparative statics results.

Proposition 6: As long as the agents have Cobb-Douglas preferences and assumption (21) holds, total contributions E_A^* to the enforcement fund in the subgame perfect equilibrium increase if

(i) other things equal, income Y increases, or

(ii) other things equal, the size of the economy n increases, and the effectiveness of sanctions $\mu(E_A)$ does not depend of n.

Proof: The right-hand side of condition (20) decreases in E_A^* given our assumptions on $\mu(E)$ while the left-hand side increases in E_A^*. Then (i) holds as the left-hand side of (20) falls when Y grows. Furthermore, (ii) is obtained because adding one agent to the economy increases the right-hand side of (20) whereas its left-hand side is constant.

In order to determine how average contributions to the enforcement fund $\widehat{e}_A^* = \frac{E_A^*}{n}$ may depend on the size of the economy, we again assume the specific type of enforcement technology as described by (11). Then equilibrium condition (20) turns into

(22) $$\frac{1}{y-\widehat{e}_A^*} == \frac{1}{(n^{\gamma-1}+\widehat{e}_A^*)}\left(\frac{\rho}{n^{-1}+n^{-\gamma}\widehat{e}_A^*+\rho}-\alpha\right).$$

Then we get additional results on the effects that are implied by an increasing size of the economy.

Proposition 7: If the agents have Cobb-Douglas preferences and the enforcement technology is given by (11) average contributions to the enforcement fund $\widehat{e}_A^*$ in the subgame perfect equilibrium are

(i) increasing in the size of the economy n.

(ii) never larger than $\frac{y}{2}$.

Proof: With the same argument as applied in the proof of Proposition 6, the assertion in part (i) follows since, given $\gamma \in [0,1]$, the right-hand side of (22) is increasing in n. If n goes to infinity, condition (22) converges to $\frac{1}{y-\overline{e}^*} = \frac{1}{\overline{e}^*}(1-\alpha)$ which gives $\overline{e}_A^* = \frac{1-\alpha}{2-\alpha}y < \frac{1}{2}y$ as an upper boundary for individual contributions to the enforcement fund.

These results which are in sharp contrast to those obtained in the standard situation of voluntary provision of an intrinsic public good (see *Andreoni* [1988]) show that free-riding in supplying the second-order public good 'enforcement' is less a problem in large societies than in small groups. Per-capita contributions to the enforcement fund do not only rise with average income but also with the size of the population. This means that also in large societies strictly positive contributions to enforcement result as a non-cooperative outcome and enforcement funds can be raised successfully by a non-governmental agency. The reason is that individuals anticipate that by contributing to enforcement with universal coverage, they are exerting pressure on themselves and on all others to contribute to the first-order public good at the second stage of the game. In small groups, specific individual motives like altruism or some willingness to execute costly punishment may help to improve public good provision. In large anonymous societies, such reliance on altruistic behavior seems less convincing – nor is it necessary, as the analysis presented here shows.

It is worth noting that Proposition 7 holds for any $\gamma \in [0,1]$. Hence, economies of scale in the enforcement technology are not essential for the result that also in large economies individuals make voluntary contributions to enforcement. Even full rivalry, i.e. $\gamma = 1$, does not destroy the incentives to invest in an enforcement technology.

Raising funds for non-governmental approval or disapproval of behavior therefore works. But does it help to increase public good provision at the second stage of the game? There are two opposing effects at work: On the one hand the agents´ incentives to contribute to the public good G are improved by means of the enforcement mechanism. On the other hand, sanctioning is costly and thus the income left for the provision of the public good is reduced when individual contributions to the enforcement fund increase. As long as there is non-rivalry in enforcement the first effect will dominate insofar as individual contributions to the public good G is strictly bounded away from zero when the economy becomes larger, as long as there is non-rivalry in enforcement. In contrast, with complete rivalry in enforcement, individual public good contributions converge to zero when the size of the economy goes to infinity. These results are stated in the following Proposition.

Proposition 8: Assume that the agents have Cobb-Douglas preferences and the enforcement technology is given by (11).

(i) If $\gamma = 0$, then there is some $\underline{g} > 0$ such that $\hat{g}(E_A^*) = \frac{\hat{G}(E_A^*)}{n} \geq \underline{g}$ for all n sufficiently large.

(ii) If $\gamma = 1$, then $\lim_{n\to\infty} \hat{g}(E_A^*) = 0$.

Proof: (i) If $\gamma = 0$ it follows from (19) that for all $n \geq 2$

(23) $$\hat{g}(E_A^*) = \frac{(1+n\hat{e}_A^*)(y-\hat{e}_A^*)}{1+n\hat{e}_A^*+n\rho} = \frac{y-\hat{e}_A^*}{1+\frac{\rho}{\frac{1}{n}+\hat{e}_A^*}}.$$

For n large enough, $\hat{e}_A^*$ becomes positive. This follows from condition (22) whose left-hand side - as a function of e_A - is strictly monotonic increasing in e_A having the value $\frac{1}{y}$ if $e_A = 0$ and converging to infinity if e_A goes to y. For $e_A = 0$, the right-hand side of (22) takes on the value $n(\frac{\rho}{n^{-1}+\rho} - \frac{\rho}{1+\rho})$ which clearly exceeds $\frac{1}{y}$ for n large enough. Since the right-hand side of (22), however, has a finite value for any $n \geq 1$, the intermediate value theorem implies that there exists some $\underline{n}$ such that both sides of (22) are equated by some $\underline{\hat{e}}_A^* > 0$. But from Proposition 7, we know that $\hat{e}_A^* > \underline{\hat{e}}_A^*$ for all $n \geq \underline{n}$, and that $\hat{e}_A^*$ is bounded above by $\frac{y}{2}$. Therefore, we get for all $n \geq \underline{n}$ that

(24) $$\hat{g}(E_A^*) \geq \underline{g} := \frac{y}{2(1+\frac{\rho}{\underline{\hat{e}}_A^*})} > 0.$$

(ii) If $\gamma = 1$ and as clearly $\hat{e}_A^* < y$, we have for all n

(25) $$\hat{g}(E_A^*) = \frac{(1+\hat{e}_A^*)(y-\hat{e}_A^*)}{1+\hat{e}_A^*+n\rho} \leq \frac{(1+y)y}{1+n\rho}$$

The assertion holds since the right-hand side of (25) converges to zero when n goes to infinity. QED

The central conclusion which can be drawn from part (i) of Proposition 8 is that even in large societies the private provision of the public good G does not necessarily break down when there is non-rival enforcement. Without enforcement, things would be quite different as then individual contributions would - in the voluntary provision equilibrium - necessarily go to zero if the size of the economy converges towards infinity. This follows from equation (23) as a special case when $\widehat{e}_A^*$ is set to zero. Thus, in a two stage game of private public good provision, voluntary contributions to norm enforcement at the first stage can support provision of the public good G at the second stage also in very large societies in which agents virtually would make no contributions to G without enforcement.

With rival enforcement as considered in part (ii) of Proposition 8, the enforcement activities still help to increase individual contributions to the public good beyond the level that would be achieved without enforcement which is $\frac{y}{1+n\rho}$. It follows from a short calculation that this holds when income y is large enough. Yet, if the size of the economy increases, then individual contributions to the public good eventually vanish. The reason is, that under conditions of rivalry of enforcement, the resources put into the enforcement fund do not produce enough strength for overcoming the free-riding incentives in the supply of the public good at stage 2 when n is large.

Table 1 shows numerical results for the case of non-rival enforcement, i.e. $\gamma = 0$, where $y = 100$, $\alpha = 0.75$ and population size varies up to $n = 10^9$. The fully informed and benevolent planner would choose the public good share in aggregate income G/Y equal to $1 - \alpha = 0.25$. This implies $g = 25$ in a first-best world. Without enforcement, that is, if $E = 0$, free-riding incentives are fully operative. The resulting non-cooperative outcome is given in the left half of Table 1. It shows that contributions to the public good vanish when n becomes large. By contrast, the right half shows the non-cooperative outcome resulting when individuals have the possibility of contributing to a public enforcement fund.

Adding e^* to g^* in Table 1, we come quite close to a public expenditure share of 25 percent in the non-cooperative equilibrium. Part of this expenditure is absorbed by the financing of enforcement measures. Due to economies of scale, if $\gamma = 0$ given the specification of the enforcement technology in (11), this part shrinks as n becomes large. The results show that non-cooperative support of public good provision through non-governmental norm enforcement can be quite efficient, even if economies are as large as the largest countries in the world. Obviously, the assumption of non-rivalry of E makes the enforcement particularly effective. This is why the utility gains shown in Table 1 (u^* compared to utility levels u^0 achieved without enforcement possibilities) are huge. In the next section, the assumption of non-rivalry is abandoned. E will be a public good only insofar as nobody is excluded from its effects.

	No enforcement ($E = 0$)		Enforcement technology Available		
n	g^0	u^0	e^*	g^*	u^*
10	3.23	73.55	0.85	23.84	100.45
10^3	0.33×10^{-1}	75.77	0.95	23.81	317.34
10^6	0.33×10^{-4}	75.79	0.95	23.81	1784.54
10^9	0.33×10^{-7}	75.79	0.95	23.81	10035.21

Table 1: Non-cooperative equilibrium when enforcement technology is not available (left half) / is available (right half). $y = 100$, $g_{First\ Best} = 25$.

In contrast, Table 2 displays numerical results for the case of full rivalry, i.e. $\gamma = 1$. We see that g^* is substantially higher than g^0 in Table 1. Also, u^* is higher than u^0.

n	e^*	g^*	u^*
10	5.59	17	94.23
10^3	18.77	0.53	129.19
10^6	19.20	0.54×10^{-3}	129.91
10^9	19.20	0.54×10^{-6}	129.91

Table 2: Non-cooperative equilibrium when enforcement technology is available under conditions of full rivalry. $y = 100$, $g_{First\ Best} = 25$.

6. Conclusions

Enforcing a norm involves a twofold public good problem. First, complying with a norm means that agents contribute a certain amount to a public good G. For instance, behaving in accordance with environmental standards improves environmental quality. This is why norm compliance is desirable in the first place. Second, enforcing the norm is also a public good, subject to the following free-rider incentive: Let others pay the funds required for financing enforcement activities. To cope with these two aspects, the determinants and the effects of non-governmental norm enforcement were analyzed in a two-stage non-cooperative contribution game.

We first characterized the size of funds raised in equilibrium when the non-governmental agency targets its activities at a subgroup of agents and invites the rest of the population to finance these activities. We then considered the alternative case of universal coverage, under which the population that finances the enforcement agency coincides with the population monitored by the agency. In both cases we showed that norm enforcement can be sustained as a non-cooperative equilibrium even in large populations with standard non-altruistic preferences.

These results explain why fund-raising for non-governmental norm enforcement is successful. In a further step, its effectiveness was examined. The purpose of norm enforcement is to induce people to contribute to a public good G. The results for the aggregate supply of G induced by non-governmental sanctioning of contribution behavior depend on the properties of the enforcement technology. If enforcement activities are non-rival – that is, if surveillance and public approval/disapproval involve mainly fixed costs – then the funds raised in non-cooperative equilibrium suffice to induce substantial G supply. Numerical calculations demonstrated that almost an efficient level of G supply can be induced through non-governmental norm enforcement – even in a society as large as the world's population. If enforcement activities are subject to rivalry – resources employed for inspection of agent j cannot be used for inspecting agent i – non-governmental norm enforcement still has a positive effect on public good provision. However, as population size approaches infinity, this effect vanishes. In sum, in a large population, establishing a satisfactory norm through non-governmental activities is more difficult (though not impossible) than raising funds for non-governmental activities.

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